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Important plant areas (IPAs) in the Fergana Valley (Central Asia): The badlands of the northern foothills

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Abstract

Here, we aimed to identify important plant areas (IPAs) in the Fergana Valley, one of the most densely human-populated regions in Central Asia with a diverse array of endemic and endangered species. The IPA programme in FV aims to identify and protect a global network of plant conservation sites. We conducted a field survey from 2018 to 2021 to re-identify specimens collected from Fergana Valley and stored at the National Herbarium of Uzbekistan (TASH). An analysis of the floristic, geobotanical and collected data allowed for the identification of the badlands in the northern foothills (Chap tract and surrounding areas) as an IPA site. We modified the interpretation of criterion A for IPAs to suit the circumstances of Mountainous Central Asia and documented the distribution of 29 species in the IPAs under these sub-criteria. To our knowledge, this is the first study to identify an IPA in Uzbekistan and provide geographic coordinates with locations for the herbarium specimens used to create the IPA set for Central Asia. Our study provides a foundation for applying future IPAs in this region, addressing specific conservation challenges, such as conserving rare and endangered species that grow outside protected areas and GIS mapping of endemic species.

Keywords
Central Asia, endemic plants, Fergana Valley, important plant areas

Introduction

Important plant areas (IPAs) are specific sites that are considered the most important locations in the world for wild plant diversity requiring proper management and protection (Anderson 2002; Plantlife International 2004). Identification of IPAs are based on three consistent criteria: the presence of threatened species, exceptional botanical richness and threatened habitats (Anderson 2002). Plantlife International (www.plantlife.org.uk) has played an important role in research development for IPA identification, including the publication of a site selection manual (Anderson 2002; Darbyshire et al. 2017; www.plantlife.org.uk) and creation of a Plantlife IPA database (www.plantlifeipa.org/home).

Currently, there are programmes and initiatives in place for IPAs in many countries, including Western (Blasi et al. 2011; Marignani and Blasi 2012), Central and Eastern Europe (Anderson et al. 2005; Slashchev and Gilyashova 2010; Onyshchenko et al. 2017); Egypt (Shaltout and Eid 2010); and the Arabian Peninsula (Al-Abbasi et al. 2010; Hall et al. 2011; Llewellyn et al. 2011); Asiatic Russia (Artemov 2012; Olonova et al. 2013); Lebanon (Talhouk et al. 2017). IPA programmes allow us to study and protect transboundary biodiversity (Shuka and Malo 2010) and conserve endemic taxa with fragmented distributions (Onyshchenko et al. 2017). More detailed information on the geography of IPA programmes is provided by Darbyshire et al. (2017).

One of the central objectives of the IPA system is to support national decision-making from the outset of the identification process. This is key to encouraging participation, data accumulation, ownership of the results and the long-term conservation of specific plant sites. This allows connectivity between the plant and habitat data on priority sites with the diverse array of conservation frameworks that operate at the national level, such as environmental and planning legislations, protected area networks and land ownership systems. IPAs represent a pragmatic and proven approach to national plant conservation that can complement other initiatives, such as the National Biodiversity Strategies and Protected Area management (Darbyshire et al. 2017).

In Central Asia, the IPA programme is in the initial phase. Progress on IPA identification is limited due to a lack of regional data on plant distribution and diversity. Darbyshire et al. (2017) stated that there is limited and fragmented information on the rarity and threatened status of plant species and their habitats, as well as limited resources to harness existing data to fill the gaps in our knowledge. These limited resources are the primary reason for the slow progress in IPA identification in Central Asia. The first assessment of 31 IPAs was published in Kazakhstan (Dimeyeva and Vesselova 2015), based on national endemics and the Red Data Book plant species distribution. In this region, the existing protected area networks and national legislation

frequently fail to protect key plant species and their habitats. The phyto-diversity in this region consists of more than 10,000 species of vascular plants (Khassanov 2015). A number of plant species are associated with the diverse array of natural conditions, geological history and the unique botanical and geographical location of Central Asia.

Human impact on the environment by uncontrolled development and climatic changes have increased the threatened status of numerous plant species and habitats (Tojibaev et al. 2018b). In the Uzbek area of the Valley, the situation is further complicated by the lack of protected areas for the preservation of the representative plant diversity. The exceptions are four State nature monuments (Category 3 IPA in Uzbekistan) with a total area of 3,945 ha.

Therefore, the existing situation calls for optimisation of the current approach and development of new approaches to solve the problem of insufficient conservation in the region. Within the United Nations Convention on Biological Diversity (1993) framework, the IPA programme in Fergana Valley (FV) aimed to identify and protect a network of important sites to preserve plant species. As part of the IPA programme in Central Asia, IPA criteria are used to assess potential IPA sites across all countries in the region. The first site studied within the IPA programme in Central Asia are the foothills (badlands) of the Northern FV in Uzbekistan.

Materials and methods

Study area

Central Asia is an important global biodiversity hotspot (Myers et al. 2000). Since the earliest phytogeographical studies, mountainous Central Asia has been mentioned as a unique center of biodiversity and refugium with a large number of both paleo- and neo-endemic species (Tojibaev et al. 2022). According to traditional botanical-geographical usage (Grubov 1959; Lavrenko 1965; Kamelin 1973; Takhtajan 1978), Middle Asia and Central Asia are regarded as different phytogeographic regions. Middle Asia is the easternmost part of the ancient Mediterranean area and is, thus, characterised by a Mediterranean climate (i.e. moist spring and hot and dry summer) and rich flora, similar to that of the Iranian Region (Pimenov et al. 2011). However, in modern political geography, as well as in most English-language botanical literature, the term "Central Asia" dominates (Cowan 2007). In this paper, we take this region as the administrative-political unit of Asia and used the term "Central Asia" to refer to Kazakhstan, Turkmenistan, Uzbekistan, Tajikistan and Kyrgyzstan, collectively.

The FV is located in an intermountain region, covering an area of approximately 22,000 km^2, across Uzbekistan, Kyrgyzstan and Tajikistan. The Valley, which occupies an area of 80,000 km^2, is surrounded by the mountain ridges of Kurama and Chatkal in the northwest, Fergana in the northeast and Turkestan and Alay in the south (Fig. 1). The adjacent ridges reach elevations of 5000 m above sea level. There are deserts and sites with high salinity (solonchaks) in the central areas. The climate is dry and warm

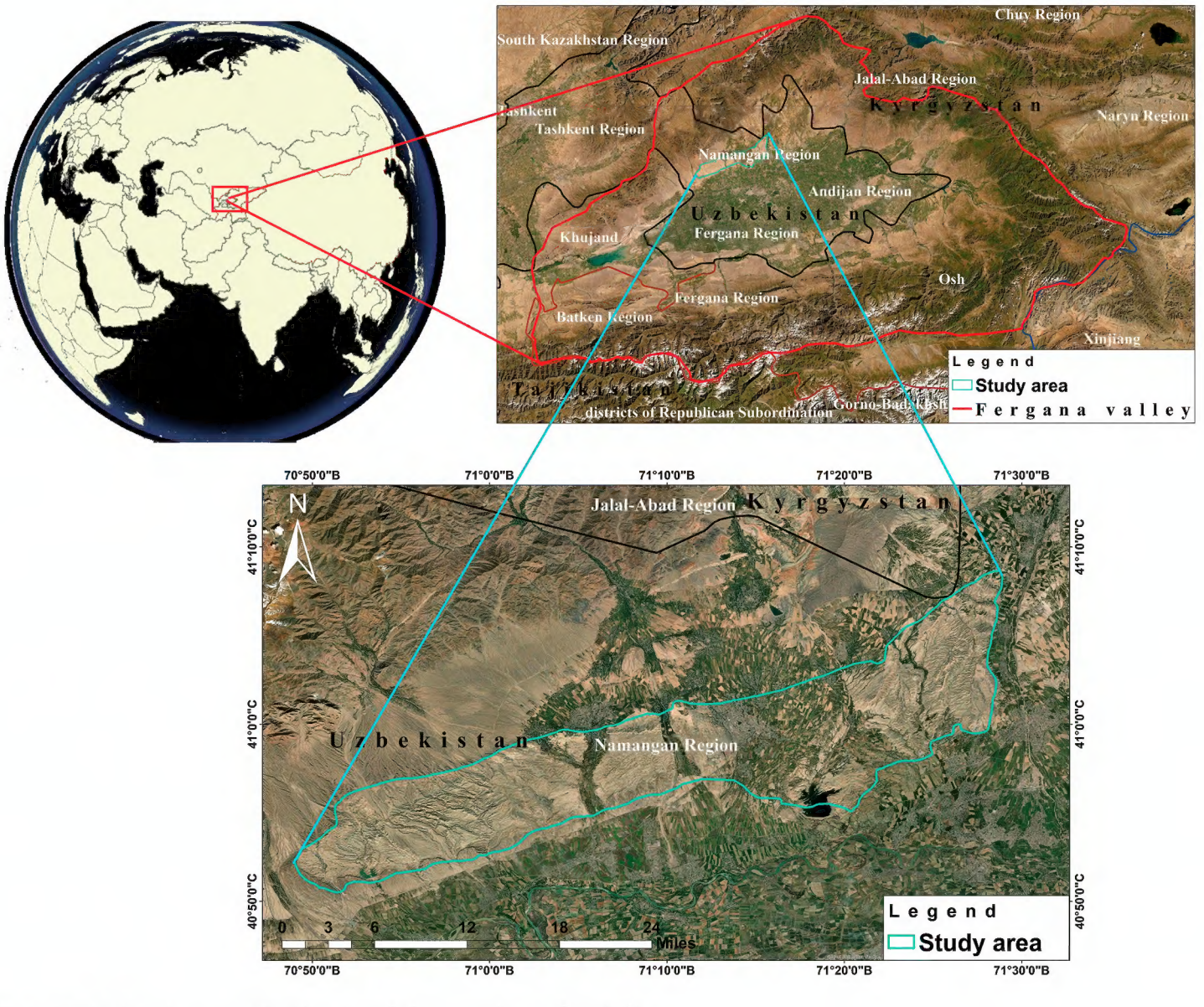

Figure 1. Study area. Badlands of the northern foothills.

(Baratov 1996). This valley is one of the most densely inhabited (300–400 people per km^2 according to CEPF 2017) and ethnically diverse regions within Central Asia. This human density has a negative impact on the natural landscape.

The badlands of the Chust-Pap foothills are located northwest of the FV. Amongst the local population, this territory is known as the "Chap" tract, which means "on the side" or "not convenient places". The IPA site occupies foothill slopes between two settlements, the Khanabad Village (in the west) and Chust Town (in the east). The study location was at 40°51'46"N, 70°48'38"E and 41° 3'35"N, 71°28'7.08"E, with elevations ranging from 350 to 890 m above sea level. The site extends 38–40 km in length and 10–12 km in width (Fig. 1).

The list of endemic taxa and borders of the Afghan-Turkestan Province were previously reported by Kamelin (1973, 1990).

Climate and geomorphology

This territory experiences the hot and dry climate of Central Fergana. Most precipitation falls in winter and the first half of spring (Table 1). In March, the temperature

Table 1. Comparative data from the two major meteorological stations in the northern areas of FV (between 2015 and 2019).

Meteorological station	Location	Altitude (m)	Annual rainfall (mm)	Max. temp. (°C)	Min. temp. (°C)	Mean temp. (°C)	Mean fog days
Namangan (2015)	40.994933, 71.594717	492	246.1	40.4	–11.5	15.6	28
Namangan (2016)	40.994933, 71.594717	492	256.7	41.6	–10.4	16.2	38
Namangan (2017)	40.994933, 71.594717	492	220.9	41.6	–8.8	15.5	42
Namangan (2018)	40.994933, 71.594717	492	175.3	42.4	–9.0	15.3	38
Namangan (2019)	40.994933, 71.594717	492	197.5	40.6	–8.4	15.8	40
Pap (2015)	40.878450, 71.111645	452	169.1	40.6	–7.9	15.7	19
Pap (2015)	40.878450, 71.111645	452	196.8	40.6	–6.9	16.1	23
Pap (2015)	40.878450, 71.111645	452	221.4	41.3	–5.7	15.5	35
Pap (2015)	40.878450, 71.111645	452	195.0	41.0	–8.8	15.3	43
Pap (2015)	40.878450, 71.111645	452	157.4	40.4	–6.3	15.7	39

reaches up to 25 °C and then rises to 40–42 °C in June, July and August. From April to August, the frequency of precipitation is low, but increases starting in early October. Snow and frost occur in December and January when the temperature is –8 to –11.5 °C (Table 1). The soil cover is slightly saline and, in some places, the salt accumulates (salt marshes) with outcrops. This area was underwater until the early Quaternary and this is reflected in the landscape structure, soil cover features and weak surface salinisation. Compared to adjacent areas, the Quaternary Lake remained for a relatively long period of time (Baratov 1996). The geomorphology significantly varies with piedmont and mountain zones in the north and irrigated agricultural lands in the south.

IPA site selection

According to Blasi et al. (2011) the number and size of IPA sites in FV were determined by the national IPA group, based on their knowledge, resources and local experience. The presence of vascular plant species of regional interest influenced our selection of IPA sites. This selection did not fully satisfy the European IPA criteria. However, these vascular plant species indirectly provide information on the conservation state of the plant community and can, consequently, be considered indicators of the floristic richness (Blasi et al. 2011).

The IPA criteria suit the arid lands of FV as they account for biodiversity at the regional and national levels. The foothills and lowlands in northern Fergana are potentially important for the preservation of endemic species, regionally threatened species and habitats. According to Blasi et al. (2009, 2011), to qualify as an IPA, a site needs to contain one or more of the following information: (A) the site holds significant populations of one or more species that are of global conservation concern; (B) the site has an exceptionally rich flora within a range of defined habitat types, in relation to its biogeographic zone; and (C) a threatened habitat or an outstanding example of a habitat type.

Following the recommendations of authoritative experts in the field, criteria A and B (Anderson 2002; Blasi et al. 2009, 2011; Darbyshire et al. 2017) were used for site

identification. The general guiding principles of the IPA methodology suggest that a site can qualify as an IPA if it satisfies any of criteria A, B, or C or any combination of these. The process of the identification of the IPA site was based on sound data, quantifiable population and area thresholds and a transparent selection process recognising the important role of national experts' opinion (Darbyshire et al. 2017).

Species were identified as a "threatened species" under Criterion A (Anderson 2002) using the IUCN Global Red List, all editions of the national Red Data Book of Uzbekistan (Khassanov 2019); and the list of National Endemics of FV (according to authors estimations; and Mountainous Central Asia (Kamelin 1973, 1990).

Additionally, we considered that the IPA site would have the necessary conditions to ensure the long-term viability of different species or infraspecific taxa. The selected site contains viable populations of a chosen species or populations that are recoverable.

Dataset, nomenclature and fieldwork

Data from the field records of selected vascular plants from different periods between 2000 to 2002, 2010 to 2015 and 2018 to 2021 were taken from the authors' collections and the Central Asia Biodiversity Conservation Network (CABCN) (http://www.cabcn.org/). We conducted fieldwork and collected more than 3,500 herbarium specimens with their geographical coordinates (Garmin Gpsmap 64s navigator) between 2018 and 2021.

The global conservation of selected species was assessed using GeoCAT (Bachman et al. 2011). By using this tool, we utilised spatially referenced primary occurrence data for the analysis of two aspects of the geographic range of an IPA taxon: the extent of occurrence (EOO) and the area of occupancy (AOO) and applied the IUCN Red List Categories and Criteria (IUCN 2021).

In total, 316 vascular plant species were recorded. The names of accepted genera and species mostly follow Plants of the World Online (POWO 2022). Additionally, we reference the recently published Checklist of Vascular Plants of the Tian-Shan Mountain System (Tojibaev et al. 2021). Digitising of the herbarium specimens was completed by scanning with HerbScan TM 224 þ Epson Expression 10000 XL (Japan), presented by the Royal Botanic Gardens in Kew, England. We also revised and georeferenced more than 3,000 herbarium specimens stored in TASH, FRU, MW and TAD Herbaria (Thiers 2021). The coordinates of the specimen records were imported into ArcGIS 10.0 and transformed into a point map layer. A WGS84 Geographic coordinate system was used as the reference datum.

Results and discussion

IPA methodology modifications

The IPA concept used was based on the criteria of Anderson (2002) and the revised global assessment presented by Darbyshire et al. (2017). As much as possible, the IPA site contained

Table 2. The FV interpretation of criterion A for important plant areas.

Sub-criterion	Description followed by Darbyshire et al. (2017)	The main group of plant species
A(i)	The site contains globally threatened species	–
A(ii)	The site contains one or more regionally threatened species	Threatened species (or infraspecific taxa) included in the Red Data Book of Uzbekistan
A(iii)	The site contains one or more highly restricted endemic species that are potentially threatened	Nationally endemic and/or regionally endemic to the FV (within three countries)
A(iv)	The site contains one or more range-restricted endemic species that are potentially threatened	Endemics to the Afghan-Turkestan Province

the full range of species on the national criterion A species list. The list of species that satisfy criterion A (threatened species) was identified by their presence in the IUCN (2021), the list of National Endemics, The Red Data Book of Uzbekistan (Khassanov 2019) and the National Red List of all three Central Asian countries containing areas of the FV. In our present research on the FV, we accepted the following interpretations of criterion A (Table 2).

National endemic taxa are restricted to individual countries whose territories include areas of the FV. Sub-endemic taxa of each country are found at a geographical unit that crosses political boundaries.

Badlands of the northern foothills (Chap tract and the surrounding areas)

The landscape of the Chap tract (Pap Adyrs, Kurama Range) resembled the badlands and difficulties in accessing this site have resulted in a lack of herbarium collections. The badlands are located within an area 550–850 m above sea level and stretch for 53 km from west to east (Fig. 1). An analysis of the floristic and geobotanical data for the FV demonstrated the effectiveness of existing methodologies in the identification of IPAs (Anderson 2002), especially in Mountainous Central Asia and FV.

The landscape of the badlands of the northern foothills resembled a lunar landscape. The rugged loess foothill slopes were covered with sparse vegetation, mainly ephemeral and halophilic shrubs (Fig. 2). Despite the inaccessibility of some areas, the badlands are used for grazing. However, the lack of water bores and sparse vegetation limits the number of livestock it can support. This favourably affects the taxonomic composition of rare species, especially bulbous geophytes. There has been a significant increase in human impact on this environment, resulting in a decrease in plant diversity, ecosystem degradation, extinction of rare and endemic species populations and the replacement of natural dominant invasive species and weeds. As a result of anthropogenic pressure, only single willow trees (*Salix* ssp.), bloomy poplar (*Populus pruinosa* Schrenk) and tamarisk (*Tamarix* ssp.) remain in some parts of the Chust-Pap foothills.

The badlands IPA is the least studied region within the FV. Limited information on its flora is available, including a few geobotanical studies (Vernik and Rakhimova 1982). The list of this area's flora has expanded considerably due to the recent discoveries made over the last few years (Tojibaev and Karimov 2011; Tojibaev and Naralieva 2012; Tojibaev et al. 2018a).

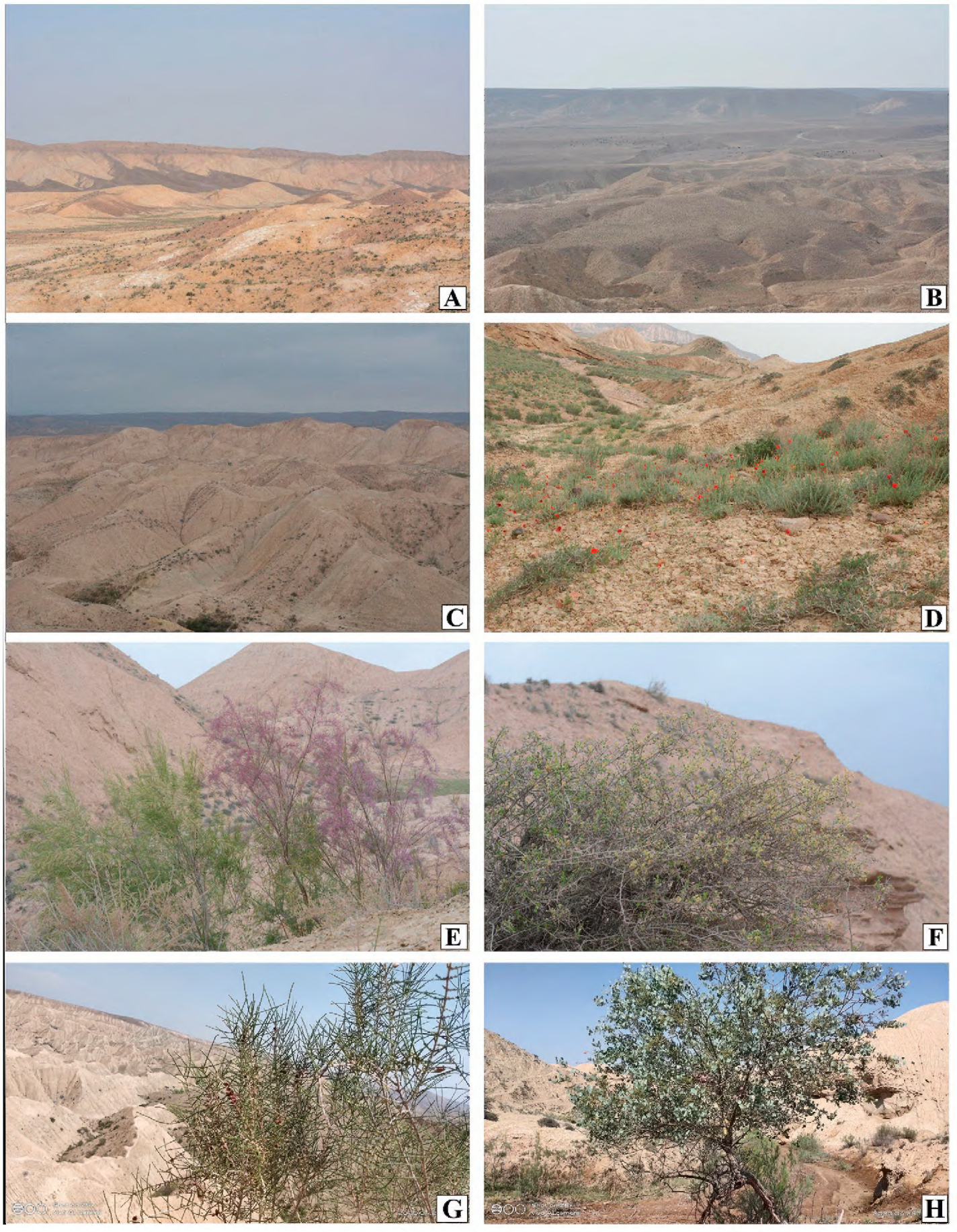

Figure 2. General view of the research area **A, B, C** the rugged loess foothill slopes, sparse vegetation, ephemeral and halophilic shrubs **D** *Papaver refractum* **E** *Tamarix ramosissima* **F** *Atraphaxis pyrifolia* **G** *Haloxylon persicum* **H** *Populus pruinosa.*

Criterion A

Twenty-nine species of vascular plants were included in criterion A. Following the national requirements (Strategy for conservation of biological diversity in the Republic of Uzbekistan for 2019–2028), we also listed national and regional species of interest (Table 3).

Table 3. The list of selected species including the criterion A of badlands of the northern foothills with IPA sub-criteria, IUCN Conservation status, general distribution and preserved herbaria.

No	Accepted species name	IPA category	Conservation status (IUCN)			Red Data Book	Preserved Herbaria
			EOO km²	AOO km²	Category		
1	*Acanthophyllum pungens* (Bunge) Boiss.	Aii	1,685,141.64	248	LC+EN	UZ	TASH, FRU, TAD, MW, AA
2	*Anthochlamys tjanschanica* Iljin ex Aellen	Aii	21,576.05	136	NT+EN	UZ	TASH, FRU, MW
3	*Dorema microcarpum* Korovin	Aii	21,800.19	46	NT+EN	KG, UZ	TASH, FRU, MW
4	*Oreosalsola drobovii* (Botsch.) Akhani	Aii	34 390,040	120	NT+EN	TJ, UZ	TASH, FRU, TAD, MW, AA
5	*Mogoltavia sewerzowii* (Regel) Korovin	Aii	9,480.84	124	VU+EN	TJ, UZ	TASH, FRU, TAD, MW
6	*Gamanthus ferganicus* Iljin	Aii	15,516,275	152	VU+EN	UZ	TASH, FRU, MW
7	*Tulipa intermedia* Tojibaev & J.de Groot	Aii	530.426	96	EN	UZ	TASH
8	*Tulipa scharipovii* Tojibayev	Aii	494.023	136	EN	UZ	TASH
9	*Acantholimon nabievii* Lincz.	Aiii	2,039.72	48	EN	–	TASH, FRU, MW
10	*Allium adylovii* sp nov. ined.	Aiii	633.28	68	EN	–	TASH
11	*Allium haneltii* F.O.Khass. & R.M.Fritsch	Aiii	865.233	36	EN	–	TASH
12	*Allium michaelis* F.O.Khass. & Tojibaev	Aiii	7,408.65	76	VU+EN	–	TASH, FRU
13	*Asparagus ferganensis* Vved.	Aiii	15,288.00	48	VU+EN	–	TASH, FRU, MW
14	*Echinops knorringianus* Iljin	Aiii	8,933.85	40	VU+EN	–	TASH, FRU, TAD, MW
15	*Astragalus namanganicus* Popov	Aiii	4,099.75	48	EN	–	TASH, FRU, MW
16	*Gagea uygursaica* Levichev & Karimov ined.	Aiii	0	4	CR	–	TASH
17	*Iris rodionenkoi* (Lazkov & Naumenko) T.Hall	Aiii	1,456.47	92	EN	–	TASH, FRU
18	*Plocama vassilczenkoi* (Lincz.) M.Backlund & Thulin	Aiii	10,923.53	100	VU+EN	–	TASH, FRU, TAD, MW
19	*Astragalus bossuensis* Popov	Aiv	61,663.17	120	LC+EN	–	TASH, FRU, AA, MW
20	*Astragalus ferganensis* (Popov) B.Fedtsch.	Aiv	18,506.70	88	VU+EN	–	TASH, FRU, MW, TAD
21	*Astragalus nematodes* Bunge ex Boiss.	Aiv	81,828.41	108	LC+EN	–	TASH, FRU, AA, MW, TAD
22	*Astragalus pseudodianthus* Nabiev	Aiv	1,169,459	32	EN	–	TASH, FRU
23	*Fritillaria stenanthera* (Regel) Regel	Aiv	52,756.56	88	LC+EN	–	TASH, AA, MW
24	*Jurinea winkleri* Iljin	Aiv	6,661.32	108	VU+EN	–	TASH, FRU, MW
25	*Limonium ferganense* Ilkonn.-Gal.	Aiv	5 203,680	12	VU+EN	–	TASH, FRU, MW
26	*Lagochilus pubescens* Vved.	Aiv	11,254.75	80	VU+EN	–	TASH, FRU, TAD MW
27	*Pseudosedum ferganense* Boriss.	Aiv	27,595.83	100	NT+EN	–	LE, MW, TASH, FRU
28	*Oxytropis gymnogyne* Bunge	Aiv	14,138.75	120	VU+EN	–	TASH, FRU, TAD MW
29	*Tulipa bifloriformis* Vved.	Aiv	15,621.72	164	VU+EN	TJ	TASH, FRU, TAD MW

Category *Ai*

Species of the category *Ai* were absent in the flora of the badlands.

Category *Aii*

Eight species were categorised under *Aii*.

The latest edition of the Red Book of Uzbekistan (Khassanov 2019) includes 324 species of vascular plants. Of these, at least 50 species are registered in the FV. Most of them are mountain species, with the maximum concentration in the Alay Range. In the Chap tract, eight species were found included in the Red Book of Uzbekistan, which accounts for 16% of all Fergana species.

***Acanthophyllum pungens* (Bunge) Boiss., Fl. Orient. 1: 561 (1867) (Figs 5A, 8A)**

= *Acanthophyllum albidum* Schischk., Fl. URSS 6: 893 (1936)

Contrary to the information given in the Red Book of Uzbekistan, the species is not "very rare" in the northern part of the FV. It grows in the foothills at an altitude of 500–800 m and inhabits loess and rocky-gravel slopes, occasionally forming dense populations of approximately 3–5 plants per 10 m^2. Threats to the species include fragmentation and habitat loss. This species does not grow in the protected areas.

General distribution: China (Xinjiang), Iran, Kazakhstan, Kyrgyzstan, Mongolia, Turkeminstan, Uzbekistan.

Distribution in FV: Foothills belt of FV.

***Anthochlamys tjanschanica* Iljin ex Aellen, Verh. Naturf. Ges. Basel 61: 170 (1950) (Figs 5A, 8B)**

A rare endemic species of FV, this species has a very narrow distribution range. It inhabits loess and rocky-gravel slopes. Threats to the species include a decrease in natural habitats and pasturing. This species does not grow in the protected areas.

General distribution: Kazakhstan, Kyrgyzstan, Tajikistan.

Distribution in FV: Northern foothills of FV.

***Dorema microcarpum* Korovin, Bot. Mater. Gerb. Inst. Bot. Zool. Akad. Nauk Uzbeksk. S.S.R. 8: 6 (1947) (Figs 3A, 5B, 8C)**

Historically, the main populations of this species were distributed over the plains, foothills and low mountains of the FV. In Uzbekistan, all previously known habitats of the species have long been developed and, in these areas, the populations of the species have already disappeared. These habitats – north of the City of Namangan and between Kokanbai and Tergachi – were fully developed for settlements in the second half of the last century. Until now, in the Red Book of Uzbekistan (Khassanov 2019), information about this species was exclusively based on historical data. All attempts to find the species in the north of the FV have been unsuccessful.

General distribution: Kyrgyzstan, Uzbekistan.

Distribution in FV: Northern foothills of FV.

***Mogoltavia sewerzowii* (Regel) Korovin, Not. Syst. Herb. Inst. Bot. & Zool. Acad. Sci. Uzbekistan 8: 11 (1947) (Figs 3B, 5B, 8E)**

According to previous data, the distribution of *M. sewerzowii* was limited by the Mogoltau massif (Tajikistan) and northern low mountains of the Alay and Turkestan Ridges (Pimenov 1983; Pimenov and Klyuikov 2002). As a rare and endangered species, it is listed in the Red Book of Uzbekistan (Khassanov 2019). Previously, the species was given for the flora of Uzbekistan (Korovin 1955), ap-

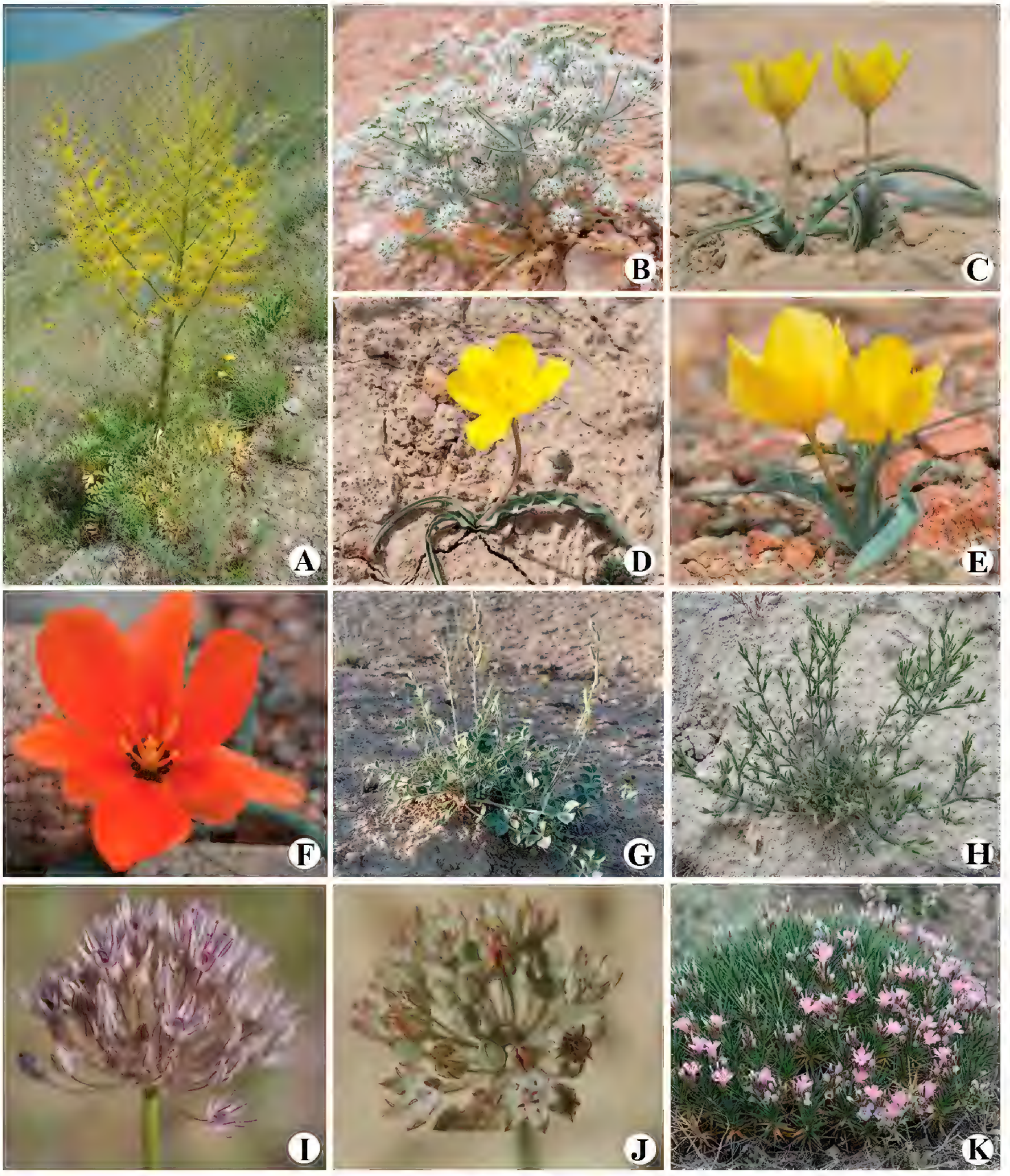

Figure 3. The wild habitat of some plants in FV **A** *Dorema microcarpum* **B** *Mogoltavia sewerzowii* **C** *Tulipa scharipovii* **D, E** *Tulipa intermedia* var. *intermedia* **F** *Tulipa intermedia* var. *korolkowoides* **G** *Astragalus namanganicus* **H** *Plocama vassilczenkoi* **I** *Allium haneltii* **J** *Allium michaelis* **K** *Acantholimon nabievii.*

parently based on two facts: a) at that time, the classical location – the Mogoltau Mountains – belonged to Uzbekistan (Tashkent Region); and b) in TASH, only one specimen of the species was collected and kept from the Fergana Region, 8 km south of the Vannovskaya station, on foothills, n°200, 3 June 1949, *Sakhobitdinov, Li*. At present, the Mogoltau Mountains are entirely within the Republic of Tajikistan and foothills near Vannovskaya station (near Margelan City, one of the most densely populated territories of the FV) have long been developed, which led

to the disappearance of the population. Based on the second fact, this species was included in two editions of the Red Book of Uzbekistan (Khassanov 2019).

General distribution: Kyrgyzstan, Tajikistan, Uzbekistan.

Distribution in FV: Northern foothills of FV and Naryn River Valley.

***Gamanthus ferganicus* Iljin, Trudy Bot. Inst. Akad. Nauk S.S.S.R., Ser. 1, Fl. Sist. Vyssh. Rast. 2: 131 (1936) (Figs 5A, 8F)**

≡ *Halimocnemis ferganica* (Iljin) Akhani, Int. J. Pl. Sci. 168: 948 (2007)

This species is rare and endemic to the foothills of FV (Pratov 1970). It grows on saline gravelly slopes. The extent of occurrence and number of populations is unknown. In the IPA site, this species was recorded only once in the northern borders. A total of 21 sheet specimens have been stored in the TASH since 1936. By the author`s estimation, the species is in decline and threatened by housing developments and urban sprawl from settlements in the FV. This species does not grow in the protected areas.

General distribution: Kyrgyzstan, Uzbekistan.

Distribution in FV: Foothills of FV.

***Oreosalsola drobovii* (Botsch.) Akhani, Phytotaxa 249: 162 (2016) (Figs 5A, 8D)**

≡ *Salsola drobovii* Botsch., Bot. Mater. Gerb. Bot. Inst. Uzbekistansk. Fil. Akad. Nauk S.S.S.R. 3: 3 (1941)

Majority of the population of this species is found in FV. This species can also be found in the Alay Ridge (Uzbekistan and Kyrgyzstan) and Central Tian-Shan and Kyrgyz Alatau in Kyrgyzstan (Lazkov and Sultanova 2011). In FV, it inhabits the clay-gravelly slopes, outcrops of gypsums rocks of the foothills and lower belt of the mountains. All known populations grow close to a large settlement (Chust, Namangan, Tashkumir) and is threatened by overgrazing. Threats include weak fruiting, low seed germination and agricultural expansion. This species does not grow in the protected areas.

General distribution: Kyrgyzstan, Uzbekistan.

Distribution in FV: Foothills and lower belt of mountains of FV.

***Tulipa intermedia* Tojibaev & J.de Groot, Nordic J. Bot. 32: 546 (2014) (Figs 3E, 5B, 8G)**

Two variations of this species have been reported, *T. intermedia* var. *intermedia* and *T. intermedia* var. *korolkowioides* (Tojibaev et al. 2014). These differ by the flower colour and stamen filaments. Both varieties grow on pebble soils along the badlands and are endemic to the foothills of Northern FV. The extent of occurrence is estimated to be less than 30 km^2. Intensive field research since 2014 has only slightly expanded the

range of the species. It inhabits stony and gravelly slopes with a dominance of *Artemisia* species. The main threats to this species include grazing and fragmentation. The current distribution of the species is not covered by the protected areas.

General distribution: Uzbekistan.

Distribution in FV: Chust-Pap foothills.

***Tulipa scharipovii* Tojibaev, Linzer Biol. Beitr. 41: 1063 (2009) (Figs 3C, 5B, 8H)**

This species is strictly endemic to the saline loess slopes of the Northern Badlands of the FV and can be classified as stenoendemic. Species recovery plans using both in situ and ex situ methods need to be developed and implemented urgently. This species does not grow in the protected areas. Both *T. scharipovii* and *T. intermedia* were initially identified and described in this region (Tojibaev 2009; Tojibaev et al. 2014). A critical situation is observed with strict endemic species of the northern foothills of the FV, both in *T. scharipovii* and *T. intermedia*. All known populations of these species grow in a zone of human activity and all populations are highly fragmented (Dekhkonov et al. 2021).

General distribution: Uzbekistan.

Distribution in FV: Chust-Pap foothills.

Recently, Dekhkonov et al. (2021) recognised the following five main threats for the conservation of rare and endangered *Tulipa* species in FV: 1) limitation of protected areas (especially in Tajikistan and Uzbekistan parts); 2) poorly managed livestock and overgrazing appear; 3) the rapid development of urban territories, rural expansion, fragmentation of natural habitats, mining activities and the corresponding loss of habitat; 4) the long horticultural history of the genus and uncontrolled collection of plants for bouquets; and 5) climate change. All of these threats are applicable to the rest of the threatened species that we have classified in category *Aii*.

Category *Aiii*

Ten species were categorised under *Aiii*.

This sub-criterion (*Aiii*) underlines the great importance of the FV as an area rich in endemic species. However, until now, there is no complete checklist of endemic plants in this region. Only endemic monocotyledonous geophytes of FV flora (Tojibaev and Karimov 2012) and some endemics belonging to the Tian-Shan part of the Valley have been published (Tojibaev et al. 2020). Based on analysis of the available data and field information, the following species were included under category *Aiii*:

***Acantholimon nabievii* Lincz., Bot. Mater. Gerb. Bot. Inst. Komarova Akad. Nauk S.S.S.R. 21: 495 (1961) (Figs 3K, 6C, 9A)**

General distribution: Kyrgyzstan, Uzbekistan.

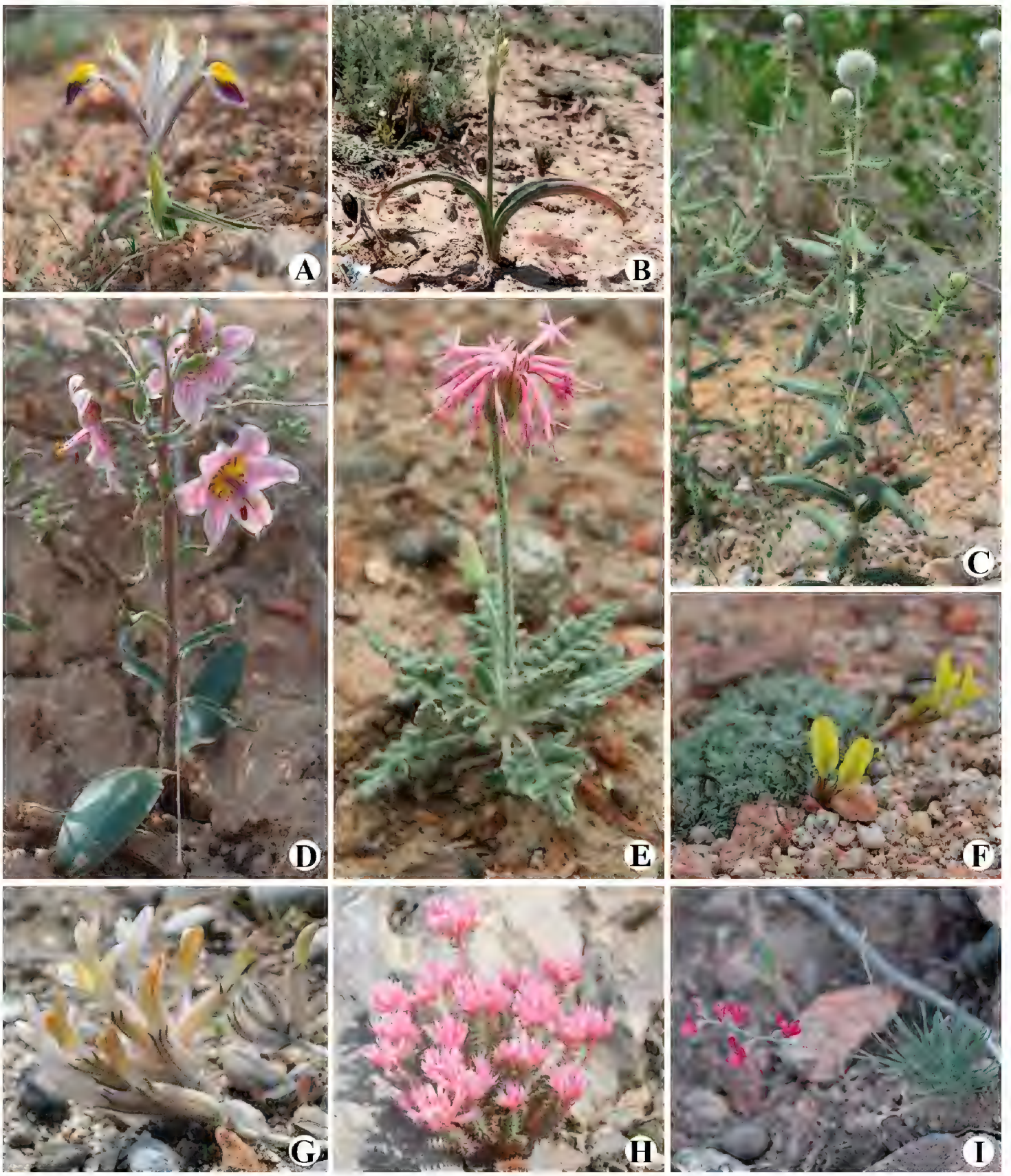

Figure 4. The wild habitat of some plants in Fergena Valley **A** *Iris rodionenkoi* **B** *Allium adylovii* **C** *Echinops knorringianus* **D** *Fritillaria stenanthera* **E** *Jurinea winkleri* **F** *Astragalus pseudodianthus* **G** *Astragalus ferganensis* **H** *Pseudosedum ferganense* **I** *Astragalus nematodes.*

Distribution in FV: Endemic, northern foothills of FV.

***Allium adylovii* Tojibaev & R.M. Fritsch ined. (Figs 4B, 6C, 9B)**

General distribution: Uzbekistan.

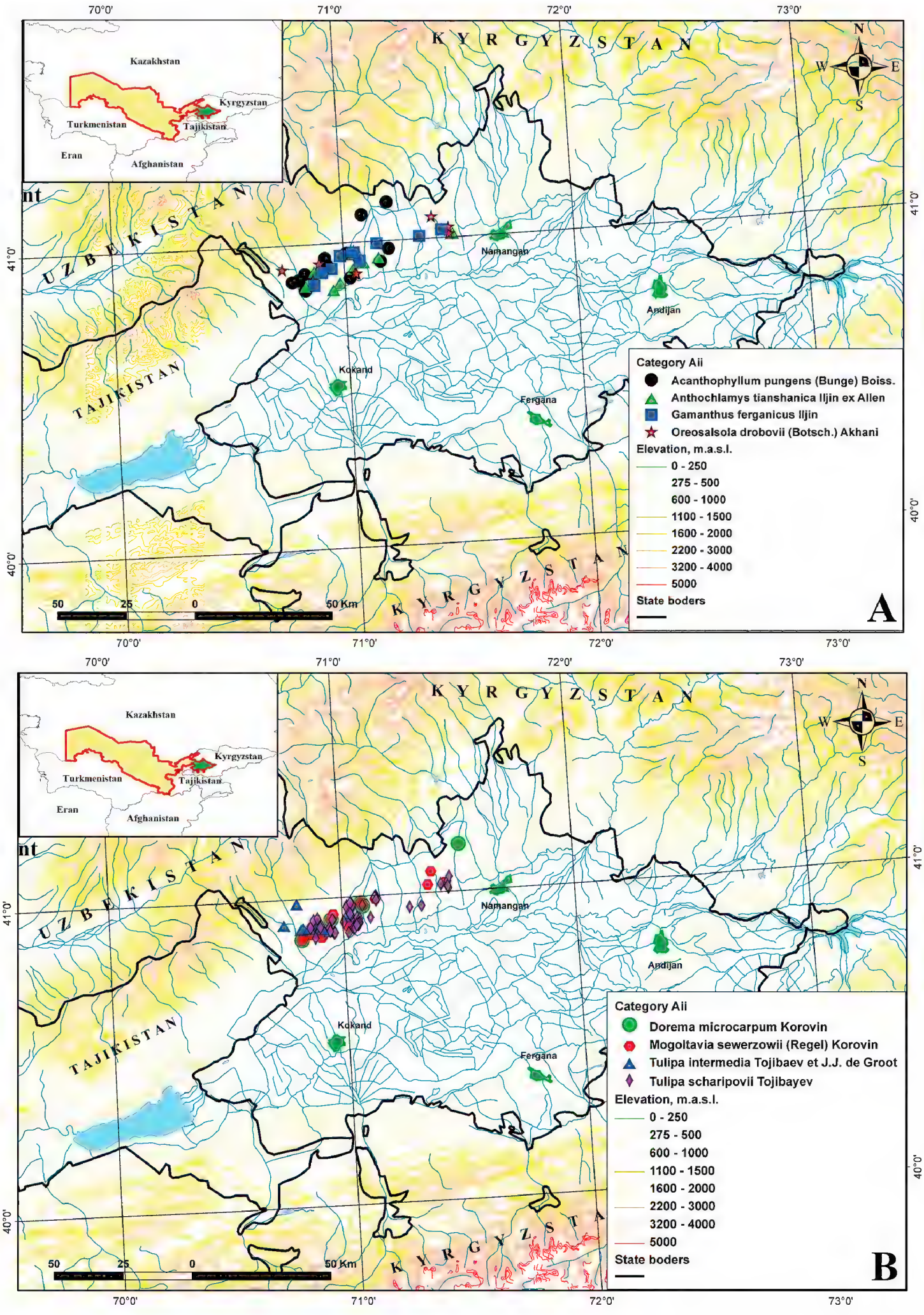

Figure 5. Distribution of species in the Aii category **A** *Acanthophyllum pungens*, *Anthochlamys tjanschanica*, *Gamanthus ferganicus*, *Oreosalsola drobovii* **B** *Dorema microcarpum*, *Mogoltavia sewerzowii* , *Tulipa intermedia*, *Tulipa scharipovii*.

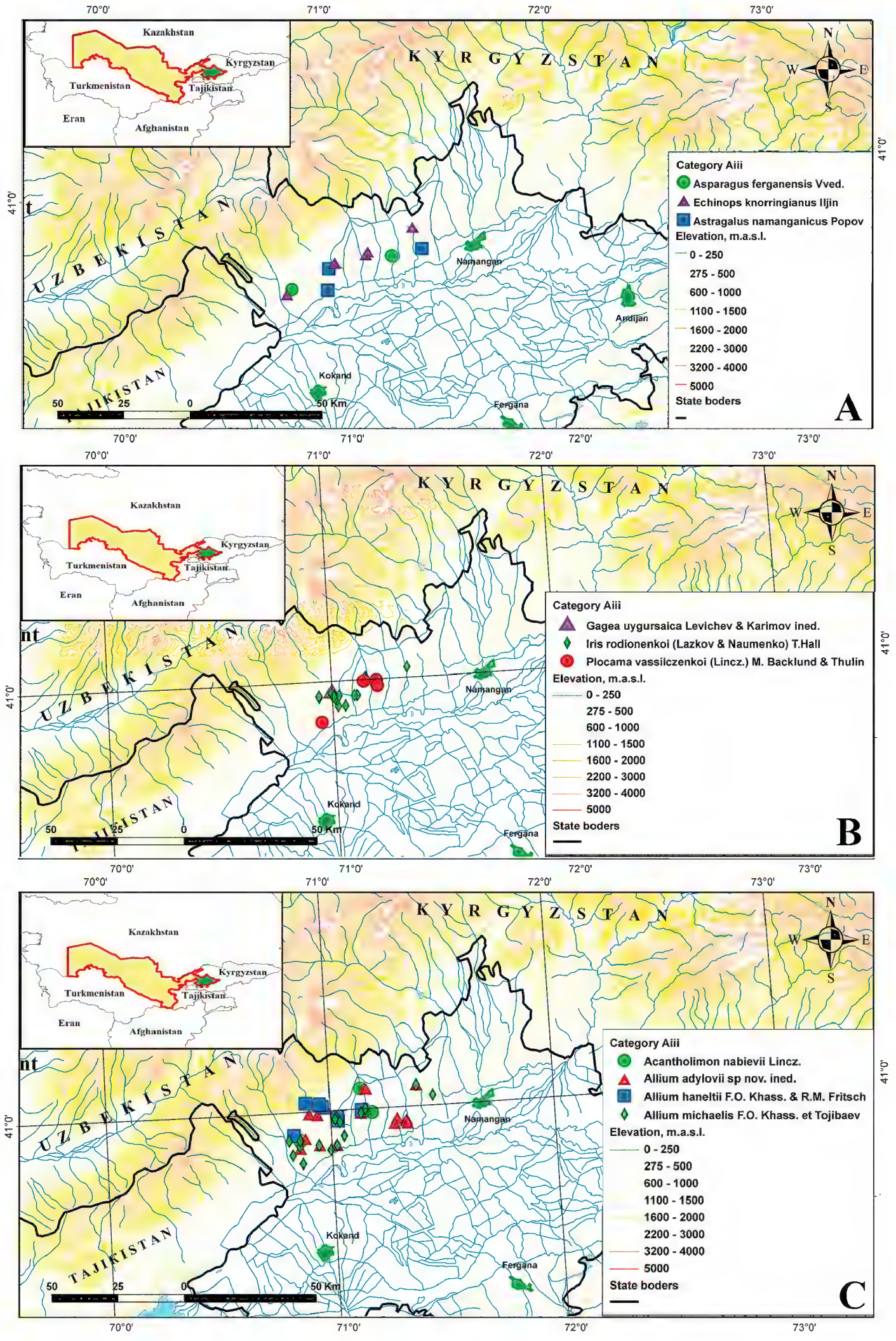

Figure 6. Distribution of species in the Aiii category **A** *Asparagus ferganensis*, *Echinops knorringianus*, *Astragalus namanganicus* **B** *Gagea uygursaica*, *Iris rodionenkoi*, *Plocama vassilczenkoi* **C** *Acantholimon nabievii*, *Allium adylovii*, *Allium haneltii*, *Allium michaelis*.

Distribution in FV: Endemic, Chap tract and surrounding loess slopes.

Allium haneltii **F.O.Khass. & R.M.Fritsch, Linz. Biol. Beitr. 30: 282 (1998) (Figs 4B, 6C, 9B)**

General distribution: Uzbekistan.
Distribution in FV: Endemic, northern foothills of FV.

Allium michaelis **F.O.Khass. & Tojibaev, Linz. Biol. Beitr. 41: 1059 (2009) (Figs 3J, 6C, 9D)**

General distribution: Kyrgyzstan, Uzbekistan.
Distribution in FV: Endemic, northern foothills of FV.

Asparagus ferganensis **Vved., Fl. Uzbekistan. 1: 544 (1941) (Figs 6A, 9E)**

General distribution: Kyrgyzstan, Tajikistan, Uzbekistan.
Distribution in FV: Subendemic, plains and foothills of FV.

Astragalus namanganicus **Popov, Byull. Sredne-Aziatsk. Gosud. Univ. 14: 140 (1926) (Figs 6A, 9E)**

General distribution: Kyrgyzstan, Uzbekistan.
Distribution in FV: Endemic; foothills and lowlands of FV.

Echinops knorringianus **Iljin, Bot. Mater. Gerb. Glavn. Bot. Sada R.S.F.S.R. 3: 173 (1922) (Figs 4C, 6A, 9F)**

General distribution: Kyrgyzstan, Tajikistan, Uzbekistan.
Distribution in FV: Endemic, northern foothills of FV.

Gagea uygursaica **Levichev & Karimov ined. (Figs 6B, 9H)**

General distribution: Uzbekistan.
Distribution in FV: Endemic, Chap tract and Uygursay.

Iris rodionenkoi **(Lazkov & Naumenko) T. Hall, Brit. Iris Soc. Newslett. 2014: 12 (2014) (Figs 4A, 6B, 9I)**

≡ *Juno rodionenkoi* Lazkov & Naumenko, Turczaninowia 17: 33 (2014)

General distribution: Kyrgyzstan, Uzbekistan.
Distribution in FV: Endemic, northern foothills of FV.

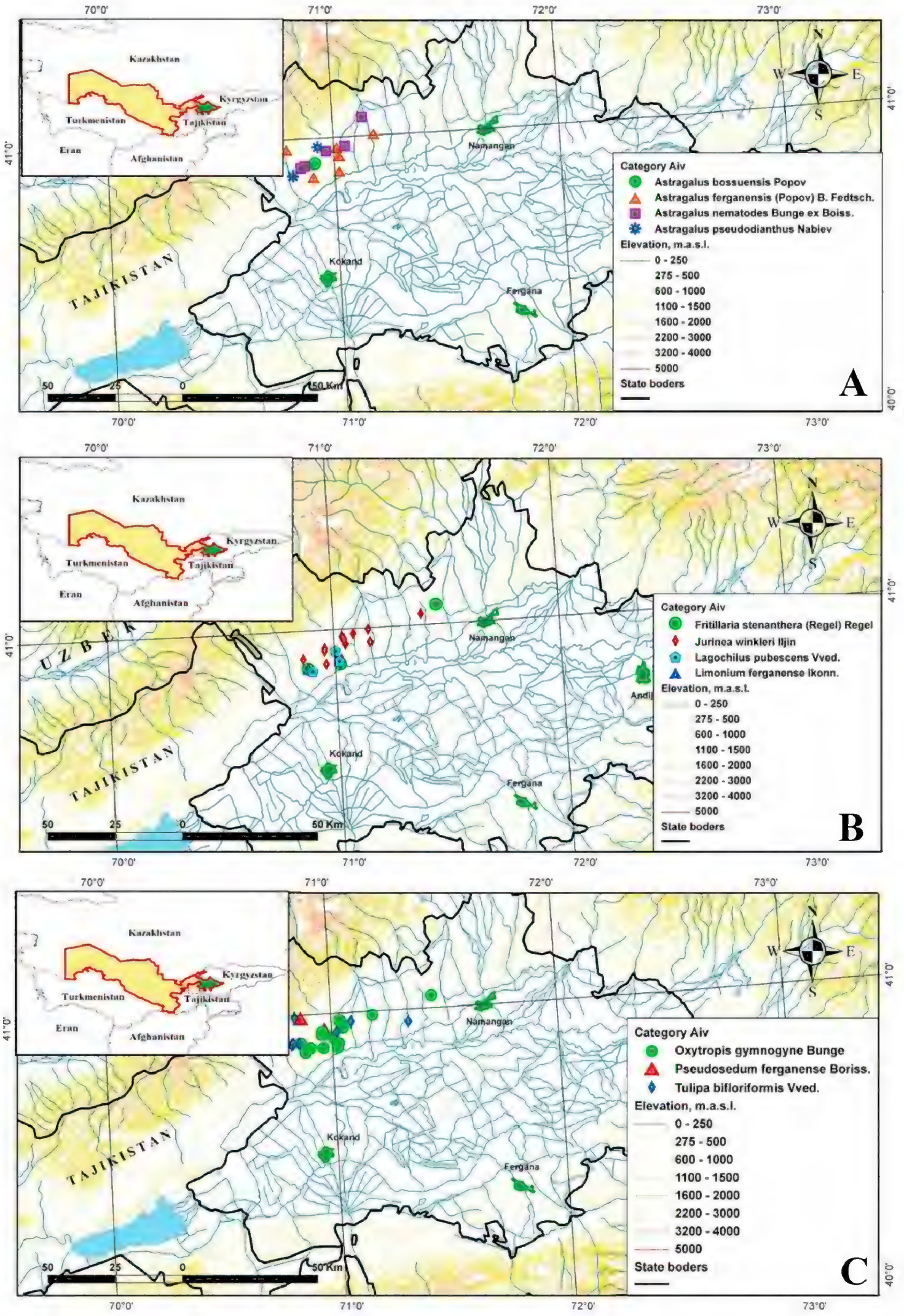

Figure 7. Distribution of species in the Aiv category **A** *Astragalus bossuensis*, *Astragalus ferganensis*, *Astragalus nematodes*, *Astragalus pseudodianthus* **B** *Fritillaris stenanthera*, *Jurinea winkleri*, *Lagochilus pubescens*, *Limonium ferganense* **C** *Oxytropis gymnogyne*, *Pseudosedum ferganense*, *Tulipa bifloriformis*.

***Plocama vassilczenkoi* (Lincz.) M. Backlund & Thulin, Taxon 56: 325 (2007) (Figs 3H, 6B, 9J)**

≡ *Neogaillonia vassilczenkoi* Lincz., Novosti Sist. Vyssh. Rast. 10: 228 (1973)

General distribution: Kyrgyzstan, Uzbekistan.

Distribution in FV: Endemic, northern foothills of FV.

Two other narrow endemics that grew in the vicinity of the badlands in the northern foothills of FV were – *Allium kuramense* F.O.Khass. & Friesen and *Allium orunbai* F.O.Khass. & R.M.Fritsch. (Tojibaev et al. 2018b).

Category *Aiv*

Eleven species were categorised under *Aiv*.

The mountainous part in the south of Central Asia, united into the Afghan-Turkestan Province (Mountainous Central Asia Province), is described in detail in the Russian literature (Kamelin 1973, 1979, 1990, 2010, 2017; Tojibaev et al. 2016), but is under-reported in English publications. The term "Afghan-Turkestan Province" was first used by Engler (1882) and, in his vision, it united part of the deserts of southern Central Asia and the Kopet Dag and Pamir-Alay Mountains. More than 5,500 species grow in this region and at least 30% of them are endemics (Kamelin 1973). Noting the newly-described genera (Khassanov and Maltzev 1993; Pimenov et al. 2011) and nomenclature combinations made in recent years, there are more than 50 endemic genera in the Province, with seven being monotypic.

***Astragalus bossuensis* Popov, Trudy Sredne-Aziatsk. Gosud. Univ., Ser. 8b, Bot. 3: 20 (1928). (Figs 7A, 10A)**

General distribution: Kazakhstan (Darbasa, Kaplanbek, Korjantau), Kyrgyzstan (Chatkal), Uzbekistan (Chatkal, Korjantau, Kurama, Ugam).

Distribution in FV: Chap tract and surrounding areas.

***Astragalus ferganensis* (Popov) B. Fedtsch. ex Korol., Fl. Tadzhiksk. S.S.R. 5: 414 (1937) (Figs 4G, 7A, 10B)**

General distribution: FV, West Tian-Shan, North and West Pamir-Alay (Kyrgyzstan, Tajikistan and Uzbekistan).

Distribution in FV: Foothills of FV.

***Astragalus nematodes* Bunge ex Boiss., Fl. Orient. 2: 425 (1872) (Figs 4I, 7A, 10C)**

General distribution: FV, West Tian-Shan (Kazakhstan, Kyrgyzstan, Tajikistan and Uzbekistan).

Distribution in FV: Chap tract, Central Fergana (Margelan).

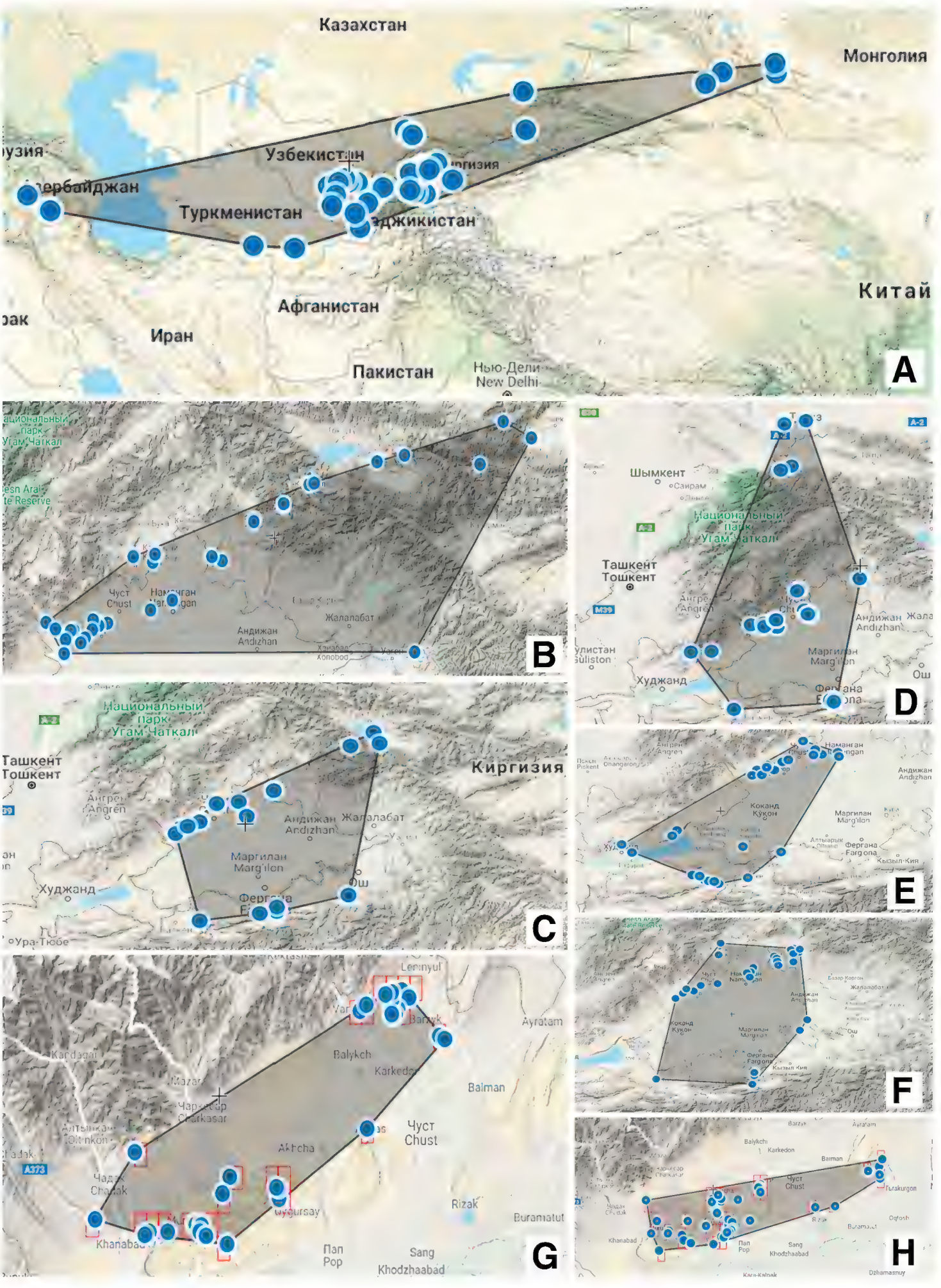

Figure 8. Distribution map of the species of sub-criterion Aii, based on GeoCAT **A** *Acanthophyllum pungens* **B** *Anthochlamys tjanschanica* **C** *Dorema microcarpum* **D** *Oreosalsola drobovii* **E** *Mogoltavia sewerzowii* **F** *Gamanthus ferganicus* **G** *Tulipa intermedia* **H** *Tulipa scharipovii*.

Astragalus pseudodianthus **Nabiev, Bot. Mater. Gerb. Inst. Bot. Akad. Nauk Uzbeksk. S.S.R. 14: 21 (1954) (Figs 4F, 7A, 10D)**

General distribution: FV, West Tian-Shan (Kazakhstan, Kyrgyzstan, Uzbekistan).

Distribution in FV: Chap tract, Kurama foothills (between Pap and Chorkesar).

Fritillaria stenanthera **(Regel) Regel, Trudy Imp. S.-Peterburgsk. Bot. Sada 8: 652 (1883) (Figs 4D, 7B, 10F)**

≡ *Rhinopetalum stenantherum* Regel, Trudy Imp. S.-Peterburgsk. Bot. Sada 3(2): 294 (1875)

General distribution: South-west Tian-Shan.

Distribution in FV: Northern foothills of FV.

Jurinea winkleri **Iljin, Fl. URSS 27: 616, 722 (1962) (Figs 4E, 7B, 10F)**

General distribution: FV, West Tian-Shan (Chatkal, Fergana, Kurama), North Pamir-Alay (Alay).

Distribution in FV: Foothills of FV (Chap, Mashat, north of Namangan, surrounds of Fergana City, Vodil).

Limonium ferganense **Ikonn.-Gal., Trudy Bot. Inst. Akad. Nauk S.S.S.R., Ser. 1, Fl. Sist. Vyssh. Rast. 2: 262 (1936) (Figs 7B, 10G)**

General distribution: West Tian-Shan (Kurama), North Pamir-Alay (Alay).

Distribution in FV: Foothills of FV (Chap tract, Vodil).

Lagochilus pubescens **Vved., Fl. URSS 21: 651 (1954) (Figs 7B, 10H)**

General distribution: FV, West Tian-Shan (Kurama, Mogoltau, Chatkal), North Pamir-Alay (Alay) (Kyrgyzstan, Tajikistan, Uzbekistan).

Distribution in FV: Foothills of FV (Shakhimardan, Sukh, Santo, Margelan, Chap).

Pseudosedum ferganense **Boriss., Trudy Bot. Inst. Akad. Nauk S.S.S.R., Ser. 1, Fl. Sist. Vyssh. Rast. 1: 112 (1933) (Figs 4H, 7C, 10I)**

General distribution: South-west Tian Shan (Chatkal and Fergana Ranges), Pamir-Alay (Alay Range).

Distribution in FV: Foothills of FV (Kurama and Chatkal Ranges).

Oxytropis gymnogyne **Bunge, Mém. Acad. Imp. Sci. Saint Pétersbourg, Sér. 7, 22: 25 (1874) (Figs 7C, 10J)**

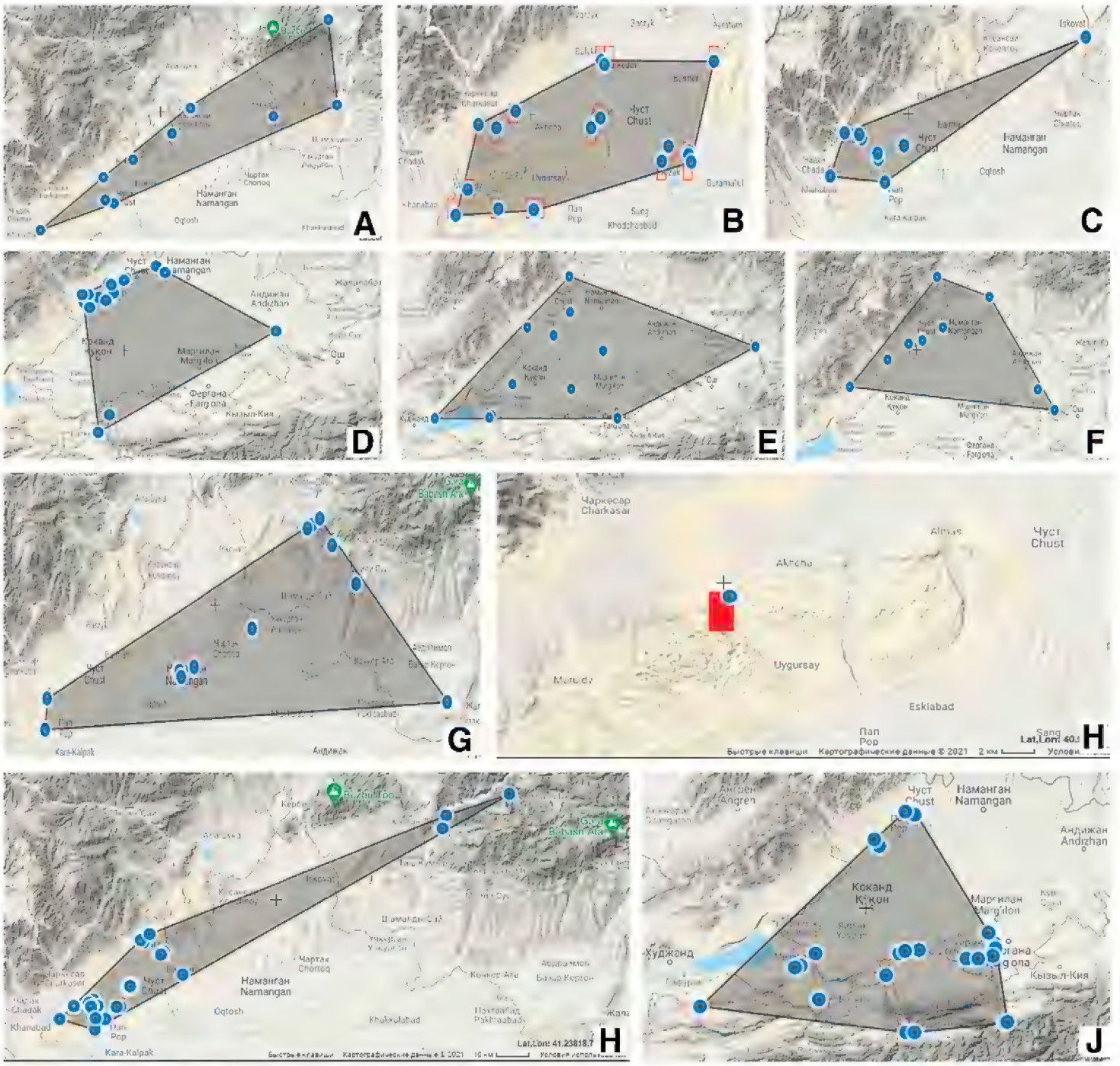

Figure 9. Distribution map of the species of sub-criterion Aiii, based on GeoCAT **A** *Acantholimon nabievii* **B** *Allium adylovii* **C** *Allium haneltii* **D** *Allium michaelis* **E** *Asparagus ferganensis* **F** *Echinops knorringianus* **G** *Astragalus namanganicus* **H** *Gagea uygursaica* **I** *Iris rodionenkoi* **J** *Plocama vassilczenkoi*.

General distribution: FV, West Tian-Shan (Chatkal, Kurama, Mogoltau).

Distribution in FV: Northern foothills of FV (Chap, Mashat).

***Tulipa bifloriformis* Vved., Opred. Rast. Sred. Azii 2: 320 (1971) (Figs 7C, 10K)**

General distribution: FV, West Tian-Shan.

Distribution in FV: Northern foothills and low mountains of FV.

As we noted above, sub-criteria *Aiii* and *Aiv* are defined differently from those used within Europe. The corresponding European IPA sub-criteria focus on threatened national endemics and national near endemics using political boundaries and threat data in the form of national Red Lists, respectively (Anderson 2002; Darbyshire et al. 2017).

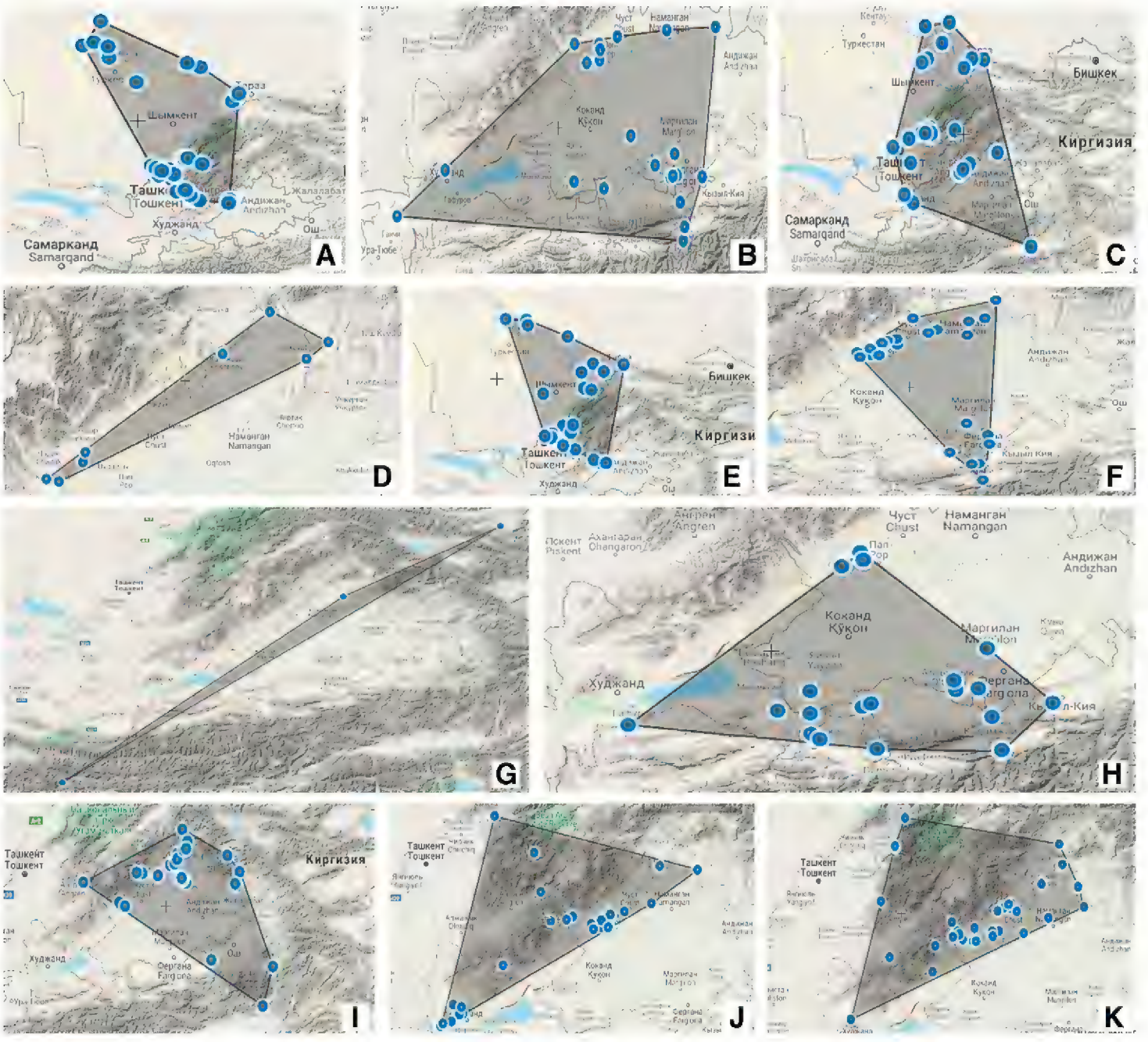

Figure 10. Distribution map of the species of sub-criterion Aiv, based on GeoCAT **A** *Astragalus bossuensis* **B** *Astragalus ferganensis* **C** *Astragalus nematodes* **D** *Astragalus pseudodianthus* **E** *Fritillaria stenanthera* **F** *Jurinea winkleri* **G** *Limonium ferganense* **H** *Lagochilus pubescens* **I** *Pseudosedum ferganense* **J** *Oxytropis gymnogyne* **K** *Tulipa bifloriformis*.

Criterion B

According to our estimates, the study area fully corresponds to the requirements for criterion B (Anderson 2002; Blasi et al. 2011; Darbyshire et al. 2017 etc.). This is justified using the data of Vernik and Rakhimova (1982). With an area of 3054 km^2, the flora of the foothills of the Namangan Region contains 364 species of vascular plants. The relatively small territory of the IPA site (634 km^2) contains at least 316 species of vascular plants, which is approximately equal to the number of species in the foothills of the Namangan Region. This high value can be explained by several reasons: first, by the real species diversity of the badlands, which are contrastingly different from the adjacent foothills; long-term field surveys; the analysis of large amount of herbarium specimens; and the predominance of anthropogenically-disturbed territories outside

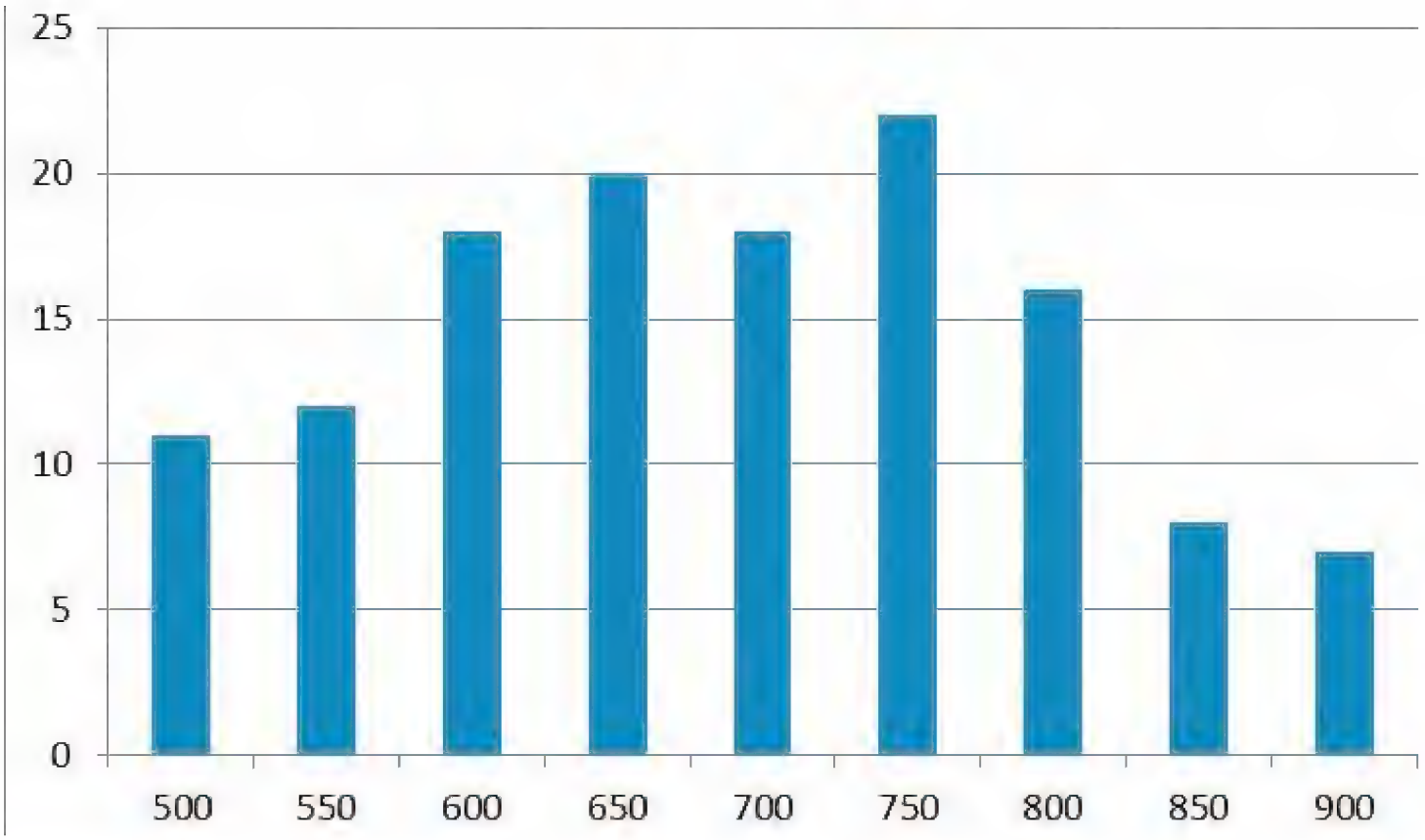

Figure 11. The altitudinal distribution of the IPA site species every 50 m.

the IPA site, amongst others. However, the high species diversity of Chust-Pap badlands not only within the FV, but also in the arid regions of Central Asia, shows the distribution of species along the gradient of height for every 50 m (Fig. 11).

Since the IPA site in the territory of the badlands of the northern foothills is geographically located in the southwest Tian-Shan, the significant participation of the geographical elements of the Turan Desert and the mountainous Pamir-Alay is of scientific interest. In addition, some of the species' distributions penetrate the neighbouring areas, but the majority were endemic species with limited distributions of less than 30 km^2.

The following plants are representatives of the Turan Desert: *Nanophyton erinaceum* (Pall.) Bunge, which is represented by large populations; annual and perennial glassworts *Salsola* ssp., *Calligonium* spp., *Artemisia* subgen. *Seriphidium* Besser ex Less., *Strigosella* Boiss., *Eremopyrum* Jaub. & Spach, *Ferula foetida* (Bunge) Regel and *Haplophyllum robustum* Bunge.

We observed a considerable influence of the flora of the western Pamir-Alay in the domination of xerophytic semi-shrubs in the ephemeroid belt of the Kurama and Chatkal Ranges. In addition, some species that were characteristic of the Pamir-Alay floras were found, although they were not previously recorded in this territory – *Lagochilus pubescens* Vved., *Arnebia obovata* Bunge, *Amberboa turanica* Iljin, *Bromus tytthanthus* Nevsky, *Scorzonera ovata* Trautv, *Cleome fimbriata* Vicary, *Andrachne telephioides* L. (*A. rotundifolia* C.A.Mey.), *Reaumuria turkestanica* Gorschk., *Tanacetopsis santoana* (Krasch., Popov & Vved.) Kovalevsk., *Artemisia namanganica* Poljak. and many others (Tojibaev et al. 2016).

In general, the flora of the badlands of the FV contained more than 316 species. Most of the endemic species to the badlands belong to the autochthonous genera, namely *Allium* L., *Astragalus* L., *Juno* Tratt. and *Tulipa* L. New IPA research conducted from 2012 to 2018 increased the known plant diversity of the northern FV by an addi-

tional fifty vascular species. Three new *Allium* species, including *Allium adylovii* Tojibaev & Fritsch ined., *Allium haneltii* F.O.Khass. & R.M.Fritsch (Fritsch et al. 1998), *Allium michaelis* F.O.Khass. & Tojibaev (Khassanov and Tojibaev 2009) and two new *Tulipa* species, including *Tulipa scharipovii* Tojibaev (Tojibaev 2009) and *Tulipa intermedia* Tojibaev & J.de Groot (Tojibaev et al. 2014), were described from the badlands of the northern foothills. Furthermore, a new species of *Iris rodionenkoi* (Lazkov & Naumenko) T.Hall that was initially described from the border regions of Kyrgyzstan (Lazkov and Naumenko 2014) was also found in this site. Two novel species (*Allium adylovii* and *Gagea uygursaica*) and two species belonging to the Apiaceae family, previously considered to have disappeared from the Uzbekistan territory, were listed for the Flora of Uzbekistan (Tojibaev and Naralieva 2012). New species belonging to the Crassulaceae and Fabaceae families were found from 2015–2016 (Tojibaev et al. 2018a) and twelve novel species in the flora of the western Tian-Shan were also reported (Tojibaev 2013). The GPS coordinates were recorded for all species and points were provided on the map, including the location of the populations of endangered species and endemics to the Valley. This process allowed us to create vector layers of floristic GIS maps using century-old data.

The IPA programme was developed in Europe and has become a widely-utilised concept worldwide for the identification of plant and habitat conservation areas (Anderson 2002; Blasi et al. 2009, 2011; Marignani and Blasi 2012; Darbyshire et al. 2017). The IPA programme may apply modifications depending on the characteristics of the country or region it is applied to and the level of database construction. Although research was conducted to select and report IPAs in Kazakhstan (Dimeyeva and Vesselova 2015), most of the criteria for the identification of IPAs presented in Europe were applied as they are, with minimal modification. In this study, IPA evaluation categories, modified to a form suitable for application to the local situation in Uzbekistan and limited to the evaluation range of species distribution in the Central Asian Mountains, were proposed.

We selected the first IPA site in Central Asia using modified criteria, based on the results of field surveys, specimens' observations and literature. Our approach to investigating biodiversity involved the maximum use of all existing data on the species geography over a long period of time to demonstrate the floristic richness and ecosystem diversity in the FV. The badlands of the northern foothills of FV located in Uzbekistan, served as a place for the approbation of modified approaches to identification of European IPA standards.

Amongst the taxa belonging to category *Aii* (Uzbekistan Red Data Book), *Tulipa intermedia* complex and *Tulipa scharipovii* are considered to be highly endemic, distributed only in the Uzbekistan territories of the FV. Both species are restricted to the Chust-Pap foothills and either their distribution range is very narrow or the population size is small, so it is considered that immediate conservation action is needed.

Amongst the taxa belonging to category *Aiii* (endemic and sub-endemic species), genus *Allium* L., which accounts for the largest proportion, originates from Central Asia which is known as the centre of diversity and about 250 species have been identified in Uzbekistan (Fritsch 2016; Li et al. 2020). In the past, six new species of *Allium* were described from the Chust-Pap foothills and their environs (Tojibaev et al. 2017). Amongst them, *Allium michaelis* F.O.Khass. & Tojibaev was primarily described from the Chap tract and was later

found in several localities of the foothills of the FV, including the territory of Kyrgyzstan. Most of the FV region is a dry land with very low vegetation coverage, dominated by shrubs or herbs. Such environmental conditions are most suitable for *Allium* species, Liliaceae in general, and also *Juno*/*Iris* species. Therefore, it is not surprising that the proportions of *Allium* and *Tulipa* are high in the species composition corresponding to Criterion A.

Conclusion

Our research was one of the first programmes to identify an IPA in Mountainous Central Asia and performed in the FV. The FV is one of the most densely human-populated regions of Middle Asia with a diverse array of endemic and endangered species. Initially, we identified the composition of the wild geophytes (Tojibaev et al. 2018b). This research was also the first to identify an IPA in Uzbekistan and provide geographic coordinates for the herbarium specimens that were used to create the IPA set for Central Asia. Further studies should focus on monitoring populations in the Central Asian mountains and endemics of the FV. Thus, they should include the number of major dominant species and changes in the composition of the flora reported in the database and GIS maps. Moreover, the principles and improvements of criterion A of the IPA proposed in this study and the data generated through our IPA programmes were, in many cases, aligned with the Plantlife International and Plantlife Important Plant Areas Database. We believe the new criteria should be adopted and refined in the preceding research in Central Asia. This initial research on the identification of IPA in Uzbekistan can contribute to the global implementation of IPA.

Acknowledgements

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